Final

Investigations of Water Quality Using Caged Mussel Bioassays and Surficial Sediment Quality at the 4H Shell Mounds

Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

Al	aluminum
AMEC	AMEC Earth & Environmental, Inc.
ANOVA	analysis of variance
As	arsenic
ASTM	American Society for Testing and Materials
Ba	barium
Be	beryllium
BHC	hexachlorocyclohexane
BOT	beginning-of-test
BP	bioaccumulation phase
C	chrysene
ºC	degrees centigrade
Calscience	Calscience Environmental Laboratory
Cd	cadmium
CI	confidence interval
Co	cobalt
COC	chain of custody
Cr	chromium
CSLC	California State Lands Commission
Cu	copper
c.v.	coefficient of variation
CVAA	cold vapor atomic absorption
cy	cubic yards
DBT	dibenzothiophene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DGPS	differential global positioning system
EOT	end-of-test
EPA	U.S. Environmental Protection Agency
ERL	effects range low
ERM	effects range medium
EST	Environmental Sampling Technologies
F	fluorene
FDA	Food and Drug Administration
Fe	iron
Fl	fluoranthene
Fl/Py	fluoranthene/pyrene
ft	feet
g	grams
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectroscopy
GFAA	graphite furnace atomic absorption
GPC	gel permeation chromatography
Hg	mercury
HMW	high molecular weight
HPLC	high-pressure liquid chromatography
ICP/MS	inductively coupled plasma mass spectrometry
I.D.	inner diameter
kg	kilogram
l	liter
lb	pounds
LC_{50}	median lethal concentration

LMW	low molecular weight
LPC	limiting permissible concentration
LCS	laboratory control sample
m	meter
MB	method blank
MDL	method detection limit
mg	milligram
µg	microgram
ml	milliliter
ML	minimum level
MLLW	mean lower low water
Mo	molybdenum
MP/P	methyl-phenanthrene/phenanthrene
MS	matrix spike
MSA	method of standard addition
MSD	matrix spike duplicate
MT	metric ton
N	naphthalene
N/A	not applicable
NBS	National Bureau of Standards
ng	nanogram
Ni	nickel
NS&T	National Status and Trends
OPR	on-going precision and recovery
p	probability
P-A	phenanthrene-Anthracene
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyls
PPE	personal protective equipment
ppt	parts per thousand
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RIS	Recovery Internal Standard
RL	reporting limit
RSD	relative standard deviation
RWQCB	Regional Water Quality Control Board
SAIC	Science Applications International Corporation
SAP	sampling and analysis plan
Sb	antimony
Se	selenium
SIM	selected ion monitoring
SIS	surrogate internal standard
SNK	Student-Newman-Kuels
SOP	standard operating procedures
SP	solid phase
SPMD	semi-permeable membrane device
SPP	suspended particulate phase
SRM	standard reference material
T_0	time zero
Tl	thallium
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbon
TS	total solids
UCSB	University of California, Santa Barbara
USACE	U.S. Army Corps of Engineers
WAWW	whole animal wet weight
WQC	water quality criteria
V	vanadium
Zn	zinc

EXECUTIVE SUMMARY

The California State Lands Commission (CSLC) is evaluating removal options for shell mounds at the sites of four previously decommissioned offshore oil and gas platforms - *Hilda*, *Hazel, Hope,* and *Heidi* (i.e., the 4H Platforms) - in the Santa Barbara Channel. Previous testing has shown that concentrations of several chemical contaminants, such as metals and petroleum and chlorinated hydrocarbons, were elevated in the shell mound sediments. Therefore, an important consideration for evaluating the final disposition of the shell mounds is whether and to what extent contaminants are leaching from the shell mounds to overlying waters and the long-term risks to water quality and biological resources. A separate issue related to other possible removal options (spreading in-place or knock-down) is the similarity of the physical (sediment texture) and chemical characteristics of the mound materials to those of bottom sediments in areas adjacent to the mounds. This report presents the results and findings of a water quality study, using caged mussels (i.e., *in situ* field bioassay) and semipermeable membrane devices (SPMD), at the shell mounds and appropriate reference sites that will be used to evaluate these removal options. This study also included analyses of surficial sediment quality in the vicinity of the shell mounds to evaluate the similarities in the chemical and physical characteristics of the adjacent bottom sediments with those of the shell mound materials. The study was conducted during February through April 2003. Key findings are described below.

CAGED MUSSEL STUDIES

Caged mussels are a useful sampling tool for characterizing water quality conditions because they filter chemical contaminants from water and concentrate the contaminants in their tissues to levels that are considerably higher than those in seawater. This improves analytical accuracy and the ability to detect small differences in water quality conditions. Additionally, measurements of contaminant levels in mussel tissues reflect exposure conditions over a period of several weeks, which are considered more representative of water quality conditions than those associated with a single grab sample of seawater. Twenty mussel samples were deployed for a period of 57-58 days at the shell mound and reference sites during February through April, and seventeen of the twenty moorings were recovered. Mussel survival was greater than 90% at all sites, and there were no significant differences in survival rates between the shell mounds and corresponding reference sites. All of the shell mound and reference site mussel samples exhibited significant growth, as indicated by increases in shell length, whole animal and soft tissue mass, and tissue lipid content. In some cases, growth metrics for the shell mound mussel samples were significantly higher than those for the reference sites.

Mussel tissues from the shell mounds, reference sites, and beginning-of-test samples were analyzed for metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). Statistical analyses of the concentration data did not indicate any significant differences between samples from the shell mound sites and corresponding reference sites for any of the chemical analytes. Therefore, the results demonstrated that contaminant exposures at the 4H shell mounds, expressed as bioaccumulation in mussel tissues, were not significantly different from those at reference sites. Significant differences between contaminant concentrations in the beginning-of-test mussel samples (i.e., representing the conditions of mussels prior to exposures at either the shell mound or reference sites) with those from the shell mound and reference sites were observed for some metals and organic contaminant classes. In particular, concentrations of several metals were lower, and some organic contaminant classes were higher, in the beginning-of-test mussel samples than in the shell mound and reference site samples. These differences were attributable to regional patterns in water quality conditions, greater exposures to bottom sediment-associated metals at the shell mound and reference sites than at the collection site (Platform Emmy off Huntington Beach, CA), and elevated metal concentrations in bottom waters following one or more regional upwelling events.

SPMD STUDIES

SPMDs are porous, plastic bags filled with a lipid material that removes certain classes of organic contaminants from the dissolved phase (i.e., not associated with suspended particles) of seawater. They are used as a sampling tool to characterize the relative levels of organic contaminants in waters at the shell mounds and reference sites. Laboratory contamination of the SPMD samples with PAHs and chlorinated pesticides compromised the reliability of these results. SPMD samples from the shell mound and reference sites contained concentrations and relative proportions of PAHs and chlorinated pesticides that were comparable to those measured in the dialysis blanks prepared in the laboratory during extraction of the samples. Consequently, the presence of these contaminants in the SPMD samples appeared to be primarily or entirely related to contamination from sample handling and not from exposure conditions. In contrast with the pesticide and PAH data, PCBs were not detected in any of the SPMD samples or the dialysis blank. Consequently, these results were considered reliable, and indicated that bottom waters at the shell mound sites did not contain significant amounts of dissolved PCBs.

SURFACE SEDIMENT CHARACTERIZATIONS

Characterizations of sediment quality were performed to evaluate whether the shell mound materials are being dispersed or spreading to adjacent areas of the seafloor. Analyses of sediments near the shell mounds indicated elevated barium concentrations in selected sediment samples, which is a strong indicator of drilling wastes. However, the barium concentrations did not exhibit clear spatial gradients with distance from the shell mounds. Instead, the highest barium concentrations occurred at varying distances and directions at different mound sites. These non-uniform patterns suggested that the distributions of drilling waste solids near the shell mounds may have been related to individual events, such as platform removal, vessel/ barge anchoring, and/or fish trawling that resulted in physical disturbances and displaced solids (e.g., cuttings) from the mounds, whereas it does not appear that local currents are dispersing shell mound materials. Regardless, the presence of shell mound solids contributed to the present heterogeneity of sediment quality conditions near each of the shell mounds. Other sediment quality characteristics, including grain size, total organic carbon, and concentrations of most metal and organic contaminants, in surface sediments near the shell mounds were comparable to those of the reference sites and other adjacent locations within this portion of the Santa Barbara Channel.

CURRENT AND WATER TEMPERATURE MEASUREMENTS

Current speed and direction were measured to provide information on water movement and possible transport directions for any materials leaching from the shell mounds. Currents measured near the shallow and deep shell mounds during the mussel/SPMD deployment period exhibited a predominant upcoast flow, and at directions parallel with the local orientation of the coast. Maximum current velocities were less than one-half knot (nautical mile per hour). Bottom water temperatures varied during the deployment period in response to storm events and oceanographic conditions. On at least two occasions, bottom water temperatures decreased rapidly, and likely reflected regional upwelling events. Nevertheless, water temperatures at the shell mounds were similar to those at the corresponding reference sites and, thus, were not expected to contribute to any spatial differences in mussel growth or survival which might otherwise affect the mussel tissue contaminant results.

While previous testing of sediment cores showed high concentrations of several chemical contaminants, such as metals, petroleum hydrocarbons, and PCBs, in the shell mounds, results from the mussel bioassays demonstrated that these contaminants were not being released in measurable amounts into overlying waters. These results are consistent with the presence of some contaminant classes that typically are susceptible to degradation, such as volatile aromatic hydrocarbons, in the middle strata of the mounds. Because these aromatic compounds have weak affinities for particles, and readily dissolve in water, it is unlikely that they would have persisted for more than 30 years in the shell mounds if active exchange with overlying waters is occurring. Instead, soluble compounds as well as other contaminants with stronger affinities for particles have persisted in the shell mounds for several decades, and it does not appear that the contaminants are leaching from the shell mounds during normal or severe storm conditions.